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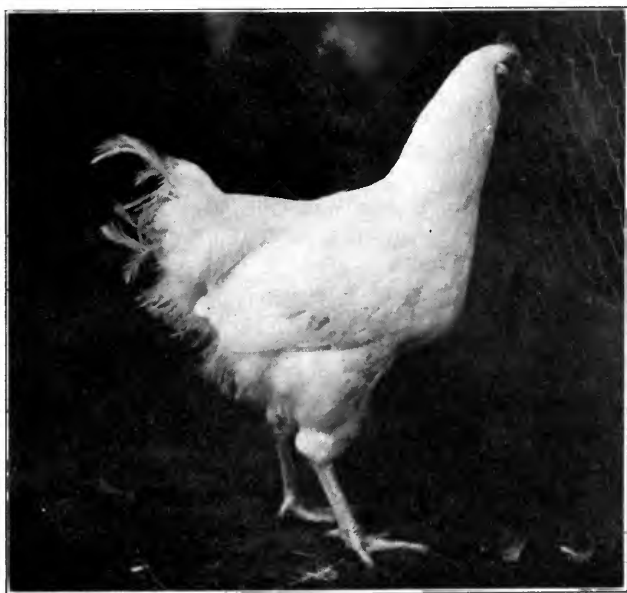
UNIVERSITY OF ILLINOIS

Agricultural Experiment Station

BULLETIN NO. 279

THE TOXICITY OF SALT FOR CHICKENS

By H. H. MITCHELL, L. E. CARD, AND G. G. CARMAN



The presence of small amounts of salt in various feeds for poultry is not so dangerous as has commonly been believed. This bird was raised on a ration containing 8 percent of salt.

URBANA, ILLINOIS, JULY, 1926

SUMMARY

Because of the general belief that chickens are very readily poisoned by common table salt, and because of the common occurrence of salt in wastes and by-product feeds for poultry, it was considered important to determine definitely whether the use of such wastes and feeds is dangerous to health or retards growth. This experiment was planned, therefore, in order to determine (1) the maximum percentage of salt that may be fed to growing chickens without harmful results, and (2) the maximum single dose of salt that a chicken can tolerate, or the smallest dose that would cause death.

In all, 75 chickens from three breeds were used. Fifty chickens were given a basal ration made up of yellow corn, bran, dried buttermilk, steamed bone meal, and ground limestone, containing percentages of salt of 1, 2, 4, and 8. Twenty-five other chickens were used in determining the maximum single dose of salt that an adult chicken can tolerate.

It was found that chickens could be raised from 9 to 21 weeks of age on rations containing as high as 8 percent of salt with no apparently detrimental effects. While it took some time for the chickens to become accustomed to such a salty ration, they soon learned to eat it in amounts sufficient to promote a rate of growth approximately the same as that of chickens fed the check ration.

When the salt was mixed in the feed, a daily intake of 6 to 8 grams of salt per bird appeared to have no harmful effect on the birds that were 9 weeks old or older.

Salt put directly into the crop in two equal doses amounting to 12 to 16 grams daily was quickly fatal in the case of birds weighing 2 to 4 pounds each.

Salt given in solution twice daily proved to be more toxic than equal amounts consumed in the feed.

The minimum lethal single dose of salt for birds weighing from 3 to 5 pounds was found to be close to 4 grams per kilogram of body weight.

THE TOXICITY OF SALT FOR CHICKENS

By H. H. MITCHELL, L. E. CARD, AND G. G. CARMAN¹

It is a general belief among poultrymen that chickens are very readily poisoned by common table salt, and many instances have been reported in which chickens were killed by eating salt meat or fish, salty kitchen wastes, or brine left from the curing of meat or from the freezing of ice cream. It has been recommended by some writers that the proportion of salt in a mash for chickens be no higher than 5 to 10 ounces to 100 pounds of mash when the mash mixture comprises about half the total ration, and that no salt be given to young stock until they are two months old. However, only a few controlled experiments concerned with a determination of the minimum lethal dose of salt for chickens have been reported in the literature.

In 1892 Collier² reported the results of feeding varying amounts of salt to mature hens. No harmful results were noticed in these experiments involving six hens until the intake of salt reached 0.063 ounce per head per day. An intake of 0.042 ounce per head per day was not accompanied by any noticeable symptoms. In 1909 Suffran³ attempted to determine the minimum toxic dose of common salt for chickens. From experiments on 5 chickens, he concluded that a dose of 4 grams per kilogram of body weight is sufficient to produce death, tho one chicken in the experiment resisted this dose successfully. Salt was administered in solution and was injected into the crop after the meal. The symptoms noticed were inability to stand, intense thirst, pronounced muscular weakness, and convulsive movements just before death. A viscous discharge from the beak was also noted. Post-mortem examination revealed lesions in many organs, but particularly hemorrhages and a severe congestion in the gastro-intestinal tract.

The attention of Edwards⁴ was directed toward the problem by a case in which several ducks, pigs, and chickens were killed by being fed the sweepings from the floor of a bakery, afterward found to contain about 22 percent of salt. The symptoms noted in the chickens were very similar to those above reported. An experiment was then

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²Collier, Peter. N. Y. Agr. Exp. Sta. (Geneva), Bul. 39, N. S. 1892.

³Suffran, F. Rev. Gen. Med. Vet. 13, No. 156, 698-705. 1909. Exp. Sta. Rec. 23, 793. 1910.

⁴Edwards, J. T. Jour. Compar. Path. and Ther. 31, 40-43. 1918.

performed upon three pigeons. Solutions containing 0.625, 1.25, and 2.50 grams of salt per kilogram of body weight, respectively, were injected into the crops of the birds. No ill effects from these doses were noted, except a temporary depression of the two birds given the largest doses. Five days later the same birds received doses amounting to 2.50, 3.33, and 4.50 grams per kilogram of body weight. The bird receiving the highest dose died in 18 hours, the bird receiving the next highest dose died in 23 hours, while the one receiving the smallest dose showed no symptoms.

Other experiments concerned with the symptoms of salt poisoning have been performed,¹ but in these experiments no attempt was made to determine the smallest toxic dose of salt. They need not, therefore, be reviewed here.

The evidence bearing on the toxicity of salt for chickens is meager and somewhat contradictory. Because of the common occurrence of salt in domestic and industrial wastes and by-product feeds that are occasionally or regularly fed to poultry, it is of importance to determine definitely whether the use of these wastes and feeds is a constant source of danger to the poultry flock. The experiments reported in this bulletin were undertaken, therefore, with two objects in view: first, to determine the effect of varying percentages of salt in the ration on the rate of growth of chickens; and second, to determine the smallest dose that would cause death.

OUTLINE OF EXPERIMENT

Five lots of 10 chicks each at the poultry farm and five lots of 5 chicks each at the nutrition laboratory were fed a well-balanced basal ration containing varying amounts of salt. Lot 1 at both the poultry plant and the nutrition laboratory received 1 percent of salt in their ration; Lot 2, 2 percent; Lot 3, 4 percent; Lot 4, 8 percent; and Lot 5, 1 percent with free access to rock salt. The lots fed at the poultry farm were kept in shelters open to the south and had the run of lots free from vegetation (Fig. 1). They were group-fed and were weighed individually each week. Feed records were kept on all lots.

The chickens grown in the laboratory were confined in individual pens having a floor space of 4 square feet. They were fed individually and were weighed weekly.

All lots had free access to feed at all times, and the chickens fed individually at the nutrition laboratory were also given as much feed as they would consume. It was hoped that all chickens in the experiment could be selected from the same breed of birds at the same age, but unfortunately this ideal could not be realized. Each lot kept at

¹Heinz and Haas. München. Med. Wehnschr. 70, 565-66. 1923.

the poultry farm contained 5 White Wyandotte chickens and 5 White Leghorn chickens. The chickens grown at the nutrition laboratory were all Rhode Island Reds. The initial age of all chickens was 8 weeks. In the distribution of the birds among the several lots, the number of cockerels and pullets in each lot was made the same.

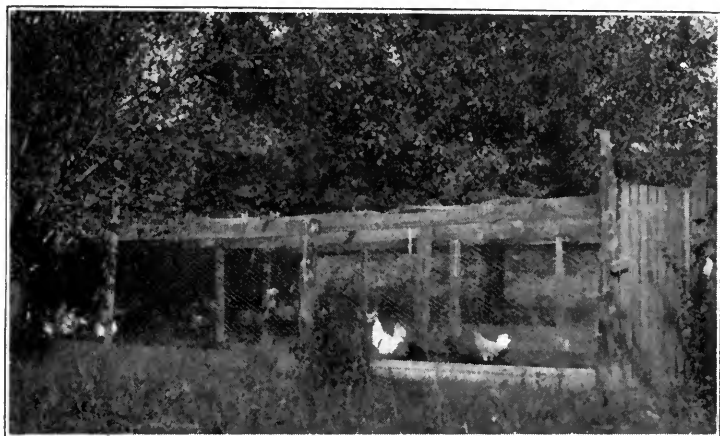


FIG. 1.—EXPERIMENTAL FEEDING PENS AT THE POULTRY PLANT USED FOR THE VARIOUS LOTS

Chicks fed at the poultry farm were kept in shelters open to the south and had the run of the lots, which were free from vegetation.

The feeding experiment at the poultry farm was continued for 13 weeks and that at the nutrition laboratory for 12 weeks. At the end of this time the birds were given salt either in capsules or in solution, in order to determine the minimum amount they could tolerate in repeated doses and the minimum single toxic dose.

EXPERIMENTAL RESULTS

The rations used at the poultry farm and at the nutrition laboratory are given in Table 1. The lots at the farm and at the laboratory receiving equal percentages of salt will be referred to by the same numbers. Lot 5 differed from Lot 1 in having access to salt at all times besides receiving 1 percent in its feed. It was found, however, that these chickens did not consume any of the salt offered to them, or if any was consumed it was so small an amount as to be obscured by the changes in moisture content of the salt offered. The salt intake of Lots 1 and 5 was therefore the same.

For the first week of the experiment all lots were fed the ration containing 1 percent salt. On June 26, 1925, the lots were put upon the

TABLE 1.—BASAL RATION AND VARIATIONS IN SALT CONTENT FOR VARIOUS LOTS OF CHICKENS

Feed	Lots 1 and 5	Lot 2	Lot 3	Lot 4
Corn.....	60	59	57	53
Wheat bran.....	15	15	15	15
Dried buttermilk.....	15	15	15	15
Steamed bone meal.....	5	5	5	5
Calcium carbonate (CaCO_3).....	4	4	4	4
Common salt (NaCl).....	1	2	4	8

Ninety-eight parts of the above mixture was in each case mixed with 2 parts of cod-liver oil.

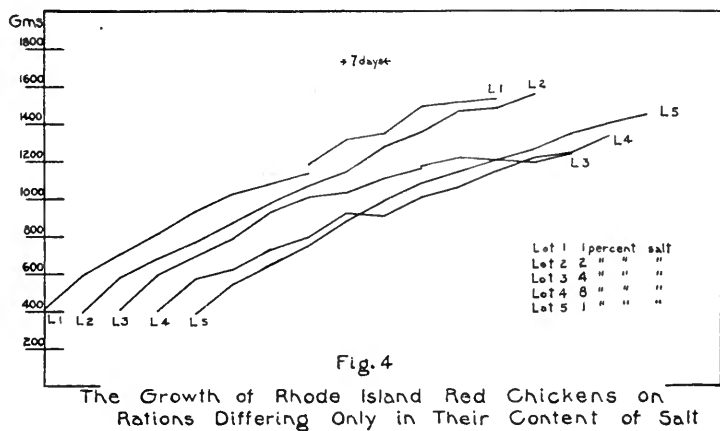
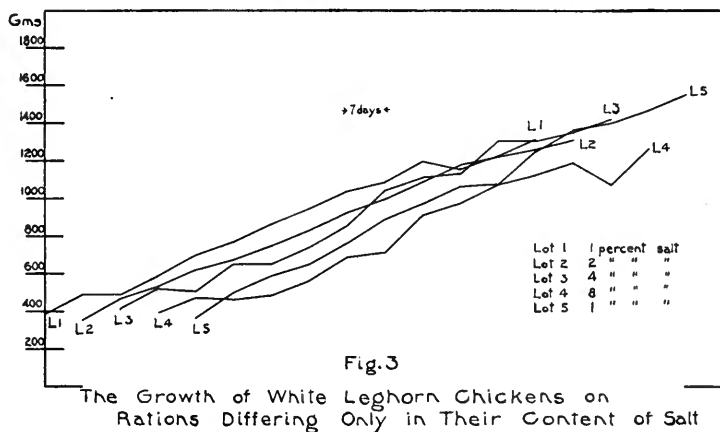
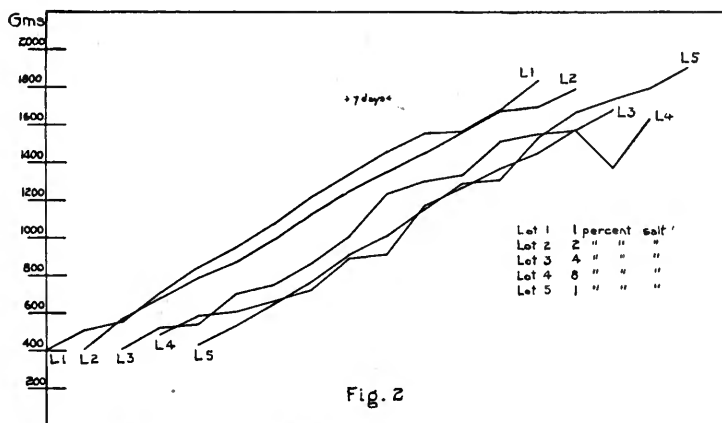
different experimental rations and kept under observation for 12 weeks in the case of the birds at the poultry plant, and for 11 weeks in the case of the birds in the nutrition laboratory.

EFFECT OF SALT ON GROWTH

The rate of growth of the White Wyandotte chickens from June 19 is shown graphically in Fig. 2, the growth of the White Leghorns in Fig. 3, and the growth of the Rhode Island Red chickens in Fig. 4. Among the lots kept at the poultry farm, the growth of Lots 1, 2, 3, and 5 was very similar. Lot 4, receiving 8 percent of salt in its ration, lagged somewhat behind the other lots in its rate of growth, altho this is mainly due to a retardation of growth in the initial weeks of the experiment because of the slow adjustment of the chickens to the extremely salty ration. When the feed intake approximated that of the other groups, the rate of growth was about the same as that of the chickens getting smaller percentages of salt.

There was some mortality among the lots kept at the poultry farm, but the cause of death seemed to be unrelated to the method of feeding. In Lots 1, 2, and 3 there were no deaths, in Lot 4 one White Wyandotte chicken died one week after experimental feeding started, and in Lot 5 two White Leghorn chickens died 11 and 32 days, respectively, after experimental feeding started. No abnormal symptoms referable to the salt intake were observed in any of the groups. Group photographs of Lots 1 and 4 getting, respectively, 1 and 8 percent of salt in their feed, are shown in Figs. 5 and 6. No differences in the condition of the two groups of birds can be seen from a comparison of these photographs. Fig. 7 shows two of the individual birds in Lot 4, one a White Leghorn and the other a White Wyandotte,¹

¹Most of the White Wyandottes used in this experiment, including the one shown in Fig. 4, had single combs.



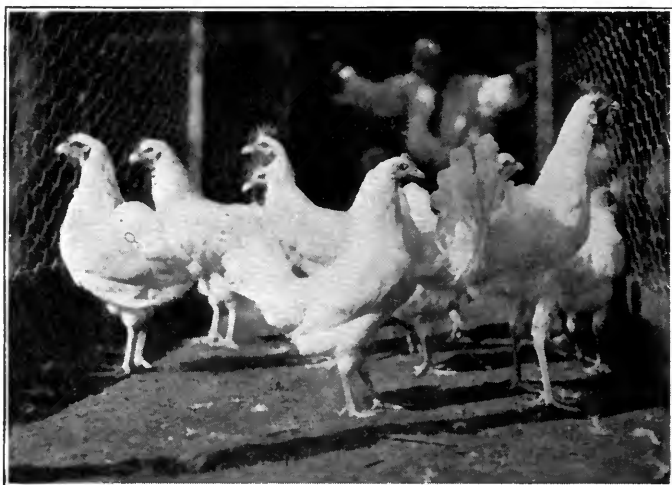


FIG. 5.—LOT 1 AFTER THIRTEEN WEEKS ON A RATION CONTAINING
1 PERCENT OF SALT

No difference could be observed in the condition of the birds in Lot 1, which received 1 percent of salt, and Lot 4, which received 8 percent (see Fig. 6).



FIG. 6.—LOT 4 AFTER THIRTEEN WEEKS ON A RATION CONTAINING
8 PERCENT OF SALT

The chickens in this lot lagged behind those in the other lots in rate of growth, owing chiefly to retardation of growth in the first weeks of the experiment before they became adjusted to the extremely salty ration. When their feed intake approximated that of the other groups, the rate of growth was about the same as for the chickens receiving less salt.

taken at the end of the feeding test. The chickens in Lot 4, particularly, drank and excreted large amounts of water, this fact accounting for their untidy appearance.

The relative growth observed among the five lots of Rhode Island Red chickens kept at the laboratory was very similar to that of the birds kept at the poultry farm. The growth in Lot 4 again was somewhat slower than that in the lots getting smaller percentages of salt, but after the birds became accustomed to the highly salty ration, the growth in Lot 4 was quite as rapid as that in the other lots; in fact it

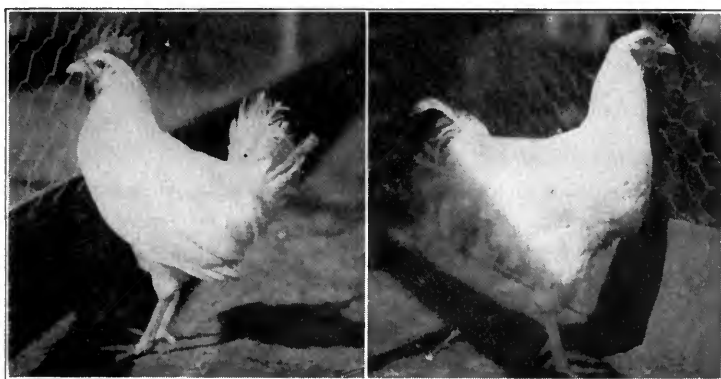


FIG. 7.—INDIVIDUAL BIRDS FROM LOT 4 FED A RATION CONTAINING 8 PERCENT OF SALT

Even this extremely salty ration did not prove to be poisonous to chickens that were eight weeks old when the experiment was started. It was observed, however, that the chickens in this lot drank and excreted large amounts of water.

was somewhat better than that observed in Lot 3, which received 4 percent of salt.

The mortality in these lots also seemed to bear no relation to the method of feeding. One chicken in Lot 1 died after 6 weeks of feeding, and 2 chickens in Lot 3 after 7 weeks of feeding. Continued growth in the lots kept in the nutrition laboratory was prevented by the appearance of leg weakness among many of the birds. Whether this was due to the small percentage of cod-liver oil in the rations or to the confinement of the birds in such small pens cannot be determined.¹ It was entirely unrelated to the salt content of the diet. The feeding experiment in the laboratory was discontinued one week sooner

¹In an attempt to determine whether the leg weakness observed was due to rickets the tibias and fibulas from each of 7 affected chickens and 5 unaffected chickens were dissected out and analyzed for ash and calcium. The bones were ground, dried, and extracted with ether before analysis. The bones from 3 of the affected birds were normal in appearance and had a normal content of ash

than that at the poultry farm, because of the prevalence of leg weakness, which interfered seriously with the feeding of many of the birds. The severity of this symptom is illustrated by the three chickens shown in Fig. 8.

The average gains and average feed records of the White Wyandotte and White Leghorn chickens fed at the poultry farm are given



FIG. 8.—BIRDS RAISED IN INDIVIDUAL FEEDING PENS IN THE NUTRITION LABORATORY

Leg weakness developed in many of the birds in the laboratory lots irrespective of the amount of salt in the rations. This condition may have been brought on by the small percentage of cod-liver oil in the rations, or by the confinement of the birds in such small pens.

in Tables 2 and 3. The average daily gains of Lots 1 and 2 receiving 1 and 2 percent of salt in the feed, respectively, were not significantly different for either breed. In Lot 3 the average daily gain of the White Leghorns was slightly higher than the gains for the same breed in Lots 1 and 2. The White Wyandottes in Lot 3, however, gained on the average rather distinctly less per day than the birds of the same breed in Lots 1 and 2. In view of the great variability among the individual gains of Lots 1 and 2, it is probable that the lower average gain in Lot 3 bears no relation to the larger intake of salt. The average daily gain of Lot 4, both with the White Wyandottes and White Leghorns, was slightly less than the average gains of the other groups, probably due to the longer time required by the chickens in this lot to become accustomed to their ration. Lot 5, receiving the same ration as Lot 1, gained on the average at a distinctly better rate, this being true of both the White Wyandotte and White Leghorn chickens that survived throughout the feeding experiment.

and calcium. The bones from 2 of the affected birds were bent, but otherwise normal in appearance, and showed a content of ash and calcium somewhat below that of most of the bones from the unaffected birds. The bones from 2 of the affected birds were bent, soft at the ends, and possessed a distinctly subnormal percentage of ash and calcium and a subnormal percentage of calcium in the ash. The bones from the unaffected birds were perfectly normal in appearance and contained an average of 58.95 percent ash and 22.35 percent calcium on the fat- and moisture-free basis, and an average of 37.91 percent calcium in the ash.

TABLE 2.—AVERAGE WEIGHTS AND GAINS OF THE WHITE WYANDOTTE AND WHITE LEGHORN CHICKENS DURING A TEST OF 84 DAYS
(All weights in grams)

WHITE WYANDOTTES							WHITE LEGHORNS					
Chick No.....	1	2	3	4	5	Average	1	2	3	4	5	Average
Lot 1—1 percent of salt												
Initial weight.....	500	490	560	490	520	512	480	550	500	410	500	488
Final weight.....	2 030	1 620	1 840	1 690	1 970	1 830	1 090	1 450	1 380	1 150	1 500	1 314
Gain.....	1 530	1 130	1 280	1 200	1 450	1 318	610	900	880	740	1 000	826
Average daily gain.	18.2	13.5	15.2	14.3	17.3	15.70	7.3	10.7	10.5	8.8	11.9	9.84
Lot 2—2 percent of salt												
Initial weight.....	430	610	570	660	590	572	400	510	490	520	420	468
Final weight.....	1 670	1 430	1 390	2 120	2 120	1 786	1 070	1 470	1 600	1 220	1 220	1 316
Gain.....	1 240	820	1 020	1 460	1 530	1 214	670	960	1 110	700	800	848
Average daily gain.	14.8	9.8	12.1	17.4	18.2	14.46	8.0	11.4	13.2	8.3	9.5	10.08
Lot 3—4 percent of salt												
Initial weight.....	420	560	450	640	550	524	460	590	570	520	480	524
Final weight.....	1 610	1 650	1 610	1 780	1 750	1 680	1 240	1 640	1 690	1 060	1 470	1 420
Gain.....	1 190	1 090	1 160	1 140	1 200	1 156	780	1 050	1 120	540	990	896
Average daily gain.	14.2	13.0	13.8	13.6	14.3	13.78	9.3	12.5	13.3	6.4	11.8	10.66
Lot 4—8 percent of salt												
Initial weight.....	530	.....¹	610	530	680	588	500	430	580	380	480	474
Final weight.....	1 300	.....	1 700	1 530	1 990	1 630	1 260	1 230	1 330	1 100	1 400	1 264
Gain.....	770	.....	1 090	1 000	1 310	1 042	760	800	750	720	920	790
Average daily gain.	9.2	.....	13.0	11.9	15.6	12.42	9.0	9.5	8.9	8.6	11.0	9.40
Lot 5—1 percent of salt												
Initial weight.....	510	460	470	610	620	534	580	470	450	.....¹	500 ³	.....
Final weight.....	1 560	2 020	1 970	2 210	1 750	1 902	1 850	1 590	1 220	.....	560	.....
Gain.....	1 050	1 560	1 500	1 600	1 130	1 368	1 270	1 120	770	.....	60	.....
Average daily gain.	12.5	18.6	17.9	18.9	13.5	16.28	15.1	13.3	9.2	.....	2.1	12.53

¹This bird died after 1 week on experiment, and is not considered in this connection. ²This bird died after 11 days on experiment. ³This bird died after 28 days on experiment. ⁴Not including No. 5.

The average daily consumption of feed in the lots kept at the poultry farm was practically the same for Lots 1, 2, 3, and 5, and slightly less for Lot 4. The average amounts of feed required per gram of gain were 6.67 grams for Lot 1, 6.72 grams for Lot 2, 6.80 grams for Lot 3, 7.01 grams for Lot 4, and 6.08 grams for Lot 5. These figures are closely related, of course, to the average daily gains of the lots—the greater the average daily gain, the smaller the average amount of feed required per gram of gain.

The feed and weight records for the Rhode Island Red chickens were obtained for each individual bird. These records with the group

TABLE 3.—FEED RECORDS FOR THE WHITE WYANDOTTE AND WHITE LEGHORN LOTS
Each lot contained 5 birds of each breed.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
	<i>grams</i>	<i>grams</i>	<i>grams</i>	<i>grams</i>	<i>grams</i>
Total feed.....	71 552	69 328	69 765	57 445	61 314
Average daily feed.	85.18	82.52	83.05	75.29	85.75
Average daily gain.	12.76	12.27	12.21	10.74	14.10
Feed per gram gain	6.67	6.72	6.80	7.01	6.08

averages are given in Table 4. The average daily gains of the five lots were, respectively, 11.64, 12.72, 9.60, 9.87, and 11.74 grams. The average daily feed intakes for the five lots were 79.6, 81.8, 69.8, 76.2, and 76.0 grams. The average economy of gains as expressed in the amount of feed required per gram of gain was approximately the same for Lots 1, 2, and 5, namely, 6.85, 6.50, and 6.66 grams, respectively. The average economy of gains in Lots 3 and 4 was distinctly less, namely, 7.99 and 7.80 grams of feed per gram of gain, tho some of the individuals in these lots were as economical in the feed cost of gains as individuals in the other lots.

It may be concluded from the results of these feeding experiments that the rate and economy of gains in growing chickens is distinctly retarded by 8 percent of salt in the diet, tho this effect is largely due to a slow adjustment of the appetite of the chickens to such a salty ration. It cannot definitely be concluded whether 4 percent of salt in the diet retards the growth of chickens. Some evidence favoring the belief that growth was retarded was obtained with White Wyandottes and Rhode Island Red chickens, tho some of the individual gains obtained on the 4-percent salt ration were as high as or higher than the gains secured on the ration containing only 1 percent of salt. The Rhode Island Red chickens receiving 4 percent of salt showed such great variation among the individual birds that the averages cannot be considered representative of the group.

TABLE 4.—AVERAGE WEIGHTS, GAINS, AND FEED CONSUMPTION OF THE RHODE ISLAND RED CHICKENS
(All weights in grams)

Lot 1—1 percent of salt					
Chick No.	1	2	3	4	5
Days on experiment.....	77	42	77	77	77
Average—					
Initial weight.....	562	537	792	574	491
Final weight.....	1 360	952	1 850	1 500	1 430
Total gain.....	798	415	1 058	926	939
Daily gain.....	10.36	9.88	13.74	12.03	12.19
Total feed.....	5 873	2 821	7 098	5 733	6 755
Average daily feed.....	76.3	67.2	92.2	74.5	87.7
Feed per gram of gain.....	7.37	6.80	6.71	6.19	7.19
Average.....					591
					11.64
					79.6
					6.85
Lot 2—2 percent of salt					
Chick No.	1	2	3	4	5
Days on experiment.....	77	77	77	77	77
Average—					
Initial weight.....	610	545	575	449	725
Final weight.....	1 850	1 560	1 450	1 300	1 640
Total gain.....	1 240	1 015	875	851	915
Daily gain.....	16.12	13.18	11.36	11.05	11.88
Total feed.....	6 972	6 727	6 594	5 551	5 663
Average daily feed.....	90.5	87.4	85.6	72.1	73.5
Feed per gram of gain.....	5.61	6.63	7.54	6.52	6.19
Average.....					581
					1 560
					979
					12.72
					81.8
					6.50

TABLE 4.—Continued

Lot 3—4 percent of salt						
Chick No.	1	2	3	4	5	Average
Days on experiment.	70	49	77	49	77	.....
Average—						
Initial weight.	758	605	512	565	551	598
Final weight.	1 230	1 036	880	1 255	1 600	.....
Total gain.	472	431	368	690	1 049	.....
Daily gain.	6.74	8.80	4.78	14.08	13.62	9.60
Total feed.	5 285	2 653	3 794	4 039	6 748	.....
Average daily feed.	75.5	54.1	49.3	82.4	87.6	69.8
Feed per gram of gain.	11.20	6.15	10.31	5.85	6.43	7.99
Lot 4—8 percent of salt						
Chick No.	1	2	3	4	5	Average
Days on experiment.	77	77	77	77	77	.....
Average—						
Initial weight.	546	569	683	587	505	578
Final weight.	1 190	1 320	1 590	1 400	1 190	1 338
Total gain.	644	751	907	813	685	760
Daily gain.	8.36	9.75	11.78	10.56	8.90	9.87
Total feed.	6 048	6 020	6 482	5 572	5 201	.....
Average daily feed.	78.5	78.2	84.2	72.4	67.5	76.2
Feed per gram of gain.	9.39	8.02	7.15	6.86	7.58	7.80

TABLE 4.—*Concluded*

Lot 5—1 percent of salt						
Chick No.....	1	2	3	4	5	Average
Days on experiment.....	77	77	77	77	77	.....
Average—						
Initial weight.....	512	608	496	590	534	548
Final weight.....	1 590	1 380	1 245	1 300	1 745	1 452
Total gain.....	1 078	772	749	710	1 211	904
Daily gain.....	14.00	10.03	9.73	9.22	15.73	11.74
Total feed.....	6 629	6 083	4 970	5 306	6 279	.....
Average daily feed.....	86.1	79.0	64.5	68.9	81.5	76.0
Feed per gram of gain.....	6.15	7.88	6.63	7.47	5.18	6.66

Information concerning the daily salt intake per bird and per kilogram of body weight is contained in Table 5 for the White Wyandotte and White Leghorn chickens, and in Table 6 for the Rhode Island Red chickens, the individual data being given in the latter case. The average daily intake of salt for all groups ranges from 0.72 gram to 6.32 grams per kilogram of body weight. The average daily intake of salt

TABLE 5.—AVERAGE SALT INTAKE PER DAY AND PER KILOGRAM OF BODY WEIGHT FOR THE WHITE WYANDOTTE AND WHITE LEGHORN CHICKENS

Each lot contained 5 birds of each breed.

	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5
	grams	grams	grams	grams	grams
Average weight.....	1 044	1 064	1 045	955	1 131
Average daily feed.....	85.18	82.52	83.05	75.29	85.75
Average daily salt intake.	0.852	1.650	3.322	6.023	0.857
Salt intake per kilogram of body weight per day.	0.816	1.551	3.179	6.306	0.758

per bird for the lots getting 8 percent in their ration was 6.32 grams for the Rhode Island Red chickens and 6.31 grams for the White Wyandottes and White Leghorns. The largest intake of salt per kilogram of body weight per day among the individual Rhode Island Red birds of Lot 4 was 6.87 grams for bird No. 1.

The figures just considered refer to the average daily intake of salt for the entire period of feeding. For the individual weeks of the experiment the intake of salt was in general higher in the early weeks. For example, in Lot 4 at the poultry farm, consisting of the White Wyandotte and White Leghorn chickens, the average intake of salt per kilogram of body weight per day for the first 4 weeks of the experiment was, in order, 5.66, 8.37, 8.75, and 6.85 grams.

The daily intake of salt per kilogram of body weight for the individual Rhode Island Red chickens in Lot 4 for all weeks of the experiment will be found in Table 7. It is evident that some of the individual birds in this group tolerated 8 to 9 grams of salt per kilogram of body weight per day without developing any pathological symptoms or showing a markedly diminished rate of growth.

MINIMUM LETHAL DOSE OF SALT

At the conclusion of the feeding experiment the birds were given varying doses of salt, either in the solid form in capsules, or in a 20-percent solution, in order to determine the maximum amount of salt that could be tolerated both in repeated doses and in single doses. In the first tests undertaken in this connection, the birds were given two doses a day at approximately 8:30 a. m. and 4:00 p. m. In these tests the doses were not adjusted to the size of the bird, but in the last test the doses were graduated according to the body weight.

The first test, which was made upon Rhode Island Red chickens from the laboratory lots, was concerned with the determination of the maximum dosage of salt that could be tolerated by the birds when given repeatedly at the rate of two doses a day. In the first day of the test two doses of 2, 4, 6, 8, and 10 grams were given groups of 3 or more birds taken from Lots 1 to 5. The salt was given by pipette in a 20-percent solution. During the test the birds had no access to feed, but water was kept before them continually except when the water containers became exhausted at night. All birds getting doses of 6, 8, and 10 grams were dead either on the afternoon of the first day or by morning of the second day. None of the birds getting 2- and 4-gram doses died during the first day. The birds surviving on the morning of the second day were therefore divided into two lots and given, respectively, 4- and 6-gram doses. Of those getting 6-gram doses, 5 survived two doses only, and 2 survived four. Of the birds getting 4-gram doses, 2 survived four doses only, 1 survived six doses, and the other bird, which was the lightest in the lot, tolerated two 4-gram doses daily for about a month with no apparent detriment. The results of the test are summarized in Table 8. The body weights given in this table were the final weights of the birds in the feeding experiment, which terminated exactly one week before this test was started.

The symptoms of the birds that died were very similar to those that have been reported in the literature. Intense thirst accompanied the treatment in all cases, and death was preceded by a period of apparent stupor in which the bird stood or squatted with closed eyes and hanging head. No pronounced convulsions were noted preceding death.

Thru the courtesy of the Laboratory of Animal Pathology and Hygiene, 9 of the birds that succumbed in this test were given post-mortem examination by Dr. E. A. Tunnicliff. The mucous membrane of the digestive tube was in all cases found to be irritated, as evidenced by hyperemia, petechia, or ecchymosis of the blood vessels. Congestion of the liver was a constant finding.

It is evident from this test that 8 grams of salt per day could not be tolerated continuously by a majority of chickens. Doses larger than 8 grams per day were quickly fatal.

In continuing the experiments in the individual dosing of birds with salt, the question arose as to whether the consumption of feed had anything to do with the survival period of the birds. The second test was therefore concerned with determining whether a difference in susceptibility to salt poisoning exists between birds in a fasting and a fed condition. Three groups of 6 birds each taken from Lots 1 to 5 at the poultry farm were given, respectively, twice daily, 4-, 5-, and 6-gram doses of salt. In each of the three groups 3 of the birds were

1. *Canis lupus* Linnaeus, 1758: *Canis* Linnaeus, 1758: 120. Type species: *Canis lupus* Linnaeus, 1758. (All wolves in genus)

Chick No.	Food 1 = 1 percent of bulk				Food 2 = 1 percent of bulk				Average			
	1	2	3	4	1	2	3	4	1	2	3	Average
Average weight	1.000				1.000				1.000			1.000
Average daily food	.70				.70				.74			.76
Average daily salt intake	0.70				0.70				0.74			0.80
total intake per kilogram body weight per day	0.009				0.009				0.010			0.010

Cuck No.	Food %				Percent of milk				Average
	1	2	3	4	1	2	3	4	
Average weight									
Average daily food	127.0		100.7		100.2		121.2		114.4
Average daily milk intake	100.0		97		100.0		70.0		100
Average daily milk intake	101		77.5		74		47		100
Average daily milk intake per kilogram body weight per day	1.44		1.70		1.00		1.10		1.49

Chick No.	Feed B					Feed C					Average
	1	2	3	4	5	1	2	3	4	5	
Average weight	1 103		805			704			635		1 004
Average daily food	75 B		74 1			40 1			62 4		107 6
Average daily milk intake	14 02		2 10			1 07			1 30		1 60
Total intake per kilogram body weight per day	2 00		2 42			2 40			1 72		2 20

TABLE 6.—*Concluded*

Lot 4—8 percent of salt					
Chick No.	1	2	3	4	5
Average weight.....	914	941	1 143	974	864
Average daily feed.....	78.5	78.2	84.2	72.4	67.5
Average daily salt intake.....	6.28	6.26	6.74	5.79	5.40
Salt intake per kilogram body weight per day.....	6.87	6.65	5.89	5.95	6.25
					Average
				
					76.2
					6.09
					6.32
Lot 5—1 percent of salt					
Chick No.	1	2	3	4	5
Average weight.....	1 076	1 040	921	1 124	1 152
Average daily feed.....	86.1	79.0	64.5	68.9	81.5
Average daily salt intake.....	0.86	0.79	0.64	0.69	0.81
Salt intake per kilogram body weight per day.....	0.80	0.76	0.70	0.61	0.71
					Average
				
					76.0
					0.76
					0.72

TABLE 7.—AVERAGE SALT INTAKE PER DAY AND PER KILOGRAM OF LIVE WEIGHT BY THE RHODE ISLAND RED CHICKENS IN LOT 4
GETTING A RATION CONTAINING 8 PERCENT OF SALT
(All weights in grams)

Week	Salt per day						Salt per day per kilogram weight					
	1	2	3	4	5	Average	1	2	3	4	5	Average
1.....	4.56	5.28	5.12	4.64	4.32	4.78	7.79	9.25	7.06	7.81	8.23	8.02
2.....	4.72	5.36	5.28	4.56	4.64	4.91	6.97	8.43	6.49	6.91	7.64	7.29
3.....	4.88	5.84	5.60	4.72	4.88	5.18	6.38	7.74	6.21	6.65	6.67	6.73
4.....	6.16	6.40	6.64	5.76	5.68	6.13	7.25	7.47	6.49	7.32	7.09	7.12
5.....	6.00	6.64	6.64	6.56	6.16	6.40	6.81	7.43	6.14	7.45	7.22	7.01
6.....	6.88	6.72	6.88	6.88	5.68	6.61	7.45	7.24	6.19	7.11	6.45	6.89
7.....	6.72	5.60	6.64	5.68	4.56	5.84	6.69	5.70	5.52	5.22	4.95	5.62
8.....	8.00	6.32	7.44	6.16	5.52	6.69	7.60	6.04	5.70	5.28	5.71	6.07
9.....	6.32	6.32	7.44	5.60	5.12	6.16	5.83	5.47	5.27	4.49	4.97	5.21
10.....	8.00	7.44	8.40	6.24	6.00	7.22	7.20	6.02	5.73	4.93	5.54	5.88
11.....	6.88	6.88	8.00	6.88	6.88	7.10	5.92	5.33	5.21	5.22	5.99	5.53

fasted during the test while the 3 remaining birds were given access to feed. The results of this test are summarized in Table 9.

The results do not show any marked differences in the survival period, whether the birds were fasting or had access to feed. A slight difference favoring the fasting birds may be noted, but it is questionable whether the difference is significant in view of the different behavior among birds given the same treatment. All doses proved to be rather quickly fatal, except in the case of one bird receiving 8 grams of salt daily, which survived for 10 days. The salt in this test was fed in the solid form and was administered in capsules.

A third test, the results of which are summarized in Table 10, was concerned with the toxicity of 3-, 4-, and 5-gram doses of salt given twice daily. While the results indicate an increased mortality with increasing dosage, it is evident that even the smallest dose could not be tolerated by these birds for any great length of time, altho the birds in Lot 4 consumed an average of over 6 grams of salt daily thruout the feeding experiment.

TABLE 8.—MINIMUM LETHAL REPEATED DOSE OF SALT FOR RHODE ISLAND RED CHICKENS

(Doses given twice daily, approximately 8:30 a. m. and 4:00 p. m.)

Bird No.	Lot	Body weight ¹	Size of dose	Number of doses taken before death
		<i>grams</i>	<i>grams</i>	
2.....	5	1 380	4	4
1.....	5	1 590	4 ²	4
3.....	4	1 590	4	6
2.....	4	1 320	4	indefinite ⁴
4.....	1	1 500	6	2
3.....	2	1 450	6	2
1.....	1	1 360	6 ²	2
1.....	2	1 850	6	2
2.....	2	1 560	6 ³	2
3.....	3	880	6 ³	4
1.....	4	1 190	6 ²	4
5.....	1	1 430	8	2
4.....	2	1 300	8	2
4.....	4	1 400	8	2
4.....	5	1 300	8	2
5.....	2	1 640	10	2
5.....	4	1 190	10	2
5.....	5	1 745	10	2

¹These weights were taken 7 days before the first dosage of salt.

²Received 2 doses of 2 grams of salt the day before.

³Received 2 doses of 4 grams of salt the day before.

⁴This chicken was given 4 grams of salt twice daily, for almost a month, at the end of which time it was in good condition.

TABLE 9.—SUSCEPTIBILITY TO SALT POISONING OF BIRDS IN FASTING AND FED CONDITIONS

Breed	Body weight ¹	Number of doses given before death					
		4-gram doses		5-gram doses		6-gram doses	
		Fasting	Fed	Fasting	Fed	Fasting	Fed
Wyandotte.....	grams						
Leghorn.....	1 560	2	..	..	..	..	..
Wyandotte.....	1 220	4	..	..	..	..	..
Wyandotte.....	2 210	20	..	..	..	..	..
Wyandotte.....	2 020	..	2	..	..	..	..
Leghorn.....	1 590	..	4	..	..	..	..
Leghorn.....	1 850	..	5	..	..	..	..
Wyandotte.....	1 970	..	..	2	..	..	..
Wyandotte.....	1 970	..	..	3	..	..	..
Leghorn.....	1 500	..	..	4	..	..	..
Leghorn.....	1 090	..	..	..	2	..	..
Wyandotte.....	1 690	..	..	..	2	..	..
Leghorn.....	1 150	..	..	..	2	..	..
Leghorn.....	1 450	..	..	..	..	2	..
Wyandotte.....	2 030	..	..	..	..	3	..
Leghorn.....	1 500	..	..	..	..	4	..
Leghorn.....	1 380	..	..	..	..	..	2
Wyandotte.....	1 840	..	..	..	..	..	2
Wyandotte.....	1 620	..	..	..	..	..	4

¹These weights were taken 3 days previous to the first dosage of salt.

In the tests so far reported, no attention was paid to the body weights of the birds, tho a study of the survival periods does not indicate that the heavier birds were markedly more resistant to salt than lighter birds given the same treatment. In the next two tests, however, the dosage was given in proportion to the live weight of the birds. In the first of these tests, three groups of 4 birds each were given, respectively, 2, 4, and 6 grams of salt per kilogram of body weight, the salt being administered in a 20-percent solution. Only one dose was given in this case, the attempt being to find the minimum lethal single dose of salt. All of the birds getting the 6-gram dose per

TABLE 10.—MINIMUM LETHAL REPEATED DOSE OF SALT FOR WHITE WYANDOTTE AND WHITE LEGHORN CHICKENS
(Doses given twice daily, approximately 8:30 a. m. and 4:00 p. m.)

Breed	Lot	Bird No.	Body weight ¹	Size of dose	Number of doses taken before death
			<i>grams</i>	<i>grams</i>	
Leghorn.....	2	2	1 470	3	3
Leghorn.....	4	3	1 330	3	3
Wyandotte.....	4	1	1 300	3	11
Leghorn.....	3	2	1 640	3	12
Wyandotte.....	4	5	1 990	3	12
Wyandotte.....	2	5	2 120	3	12
Leghorn.....	3	5	1 470	4	2
Wyandotte.....	4	3	1 700	4	2
Leghorn.....	4	2	1 230	4	2
Leghorn.....	2	3	1 600	4	3
Wyandotte.....	3	1	1 610	4	8
Leghorn.....	4	5	1 400	4	10
Wyandotte.....	2	1	1 670	4	10
Leghorn.....	2	5	1 220	5	2
Wyandotte.....	3	3	1 670	5	2
Leghorn.....	4	2	1 230	5	2
Wyandotte.....	2	4	2 120	5	3
Leghorn.....	3	3	1 690	5	3
Wyandotte.....	3	4	1 780	5	11

¹These were the final weights of the birds in the feeding experiment which ended 7 days before the test reported upon in this table.

kilogram of body weight and two of those getting the 4-gram dose were dead within 24 hours. All other birds survived the treatment. The test indicated that the minimum single lethal dose was close to 4 grams per kilogram of body weight.

In an attempt to determine the minimum lethal dosage more definitely, 6 birds from the White Wyandotte and White Leghorn groups were given, first, a single dose of 3 grams of salt per kilogram of body weight; no deaths occurred in the following 72 hours. At the end of this time they were given a second dose of 4 grams of salt per kilo-

gram of body weight, and at the end of 72 hours all birds were still alive. A third dose of 5 grams per kilogram of body weight was then administered, and within the following 24 hours 5 of the 6 birds had died with symptoms typical of salt poisoning. The remaining bird was unaffected. This test indicates rather clearly that 4 to 5 grams of salt per kilogram of body weight is close to the minimum lethal single dose of salt when administered in solution. There is no reason to suppose that these results would have been different if salt in solid form had been given, provided free access to water had been permitted, as was done in all the tests here reported. However, the preceding test indicates that 4 grams of salt per kilogram of body weight in a single dose may be fatal to some birds.

CONCLUSIONS

Chickens may be raised from 9 to 21 weeks of age on rations containing as high as 8 percent of salt with no apparent detrimental effects on their condition. Furthermore, after the birds have become accustomed to such salty rations, they will consume them in such amounts as to promote a rate of growth approximating that of birds receiving much smaller percentages of salt in their feed.

A daily intake of salt *in the feed* of 6 to 8 grams per bird appears to exert no harmful effect in birds of 9 weeks or more in age.

For birds weighing from 2 to 4 pounds each, 12 to 16 grams of salt daily administered directly in the crop in two equal doses is quickly fatal. Eight grams of salt daily, given in two doses, can ordinarily be tolerated for as long as 5 days, and occasionally indefinitely. However, even on this dosage death within 24 hours may occur in some cases. Six grams per day given in two portions is generally tolerated for 5 to 6 days, tho in a small proportion of cases death results much sooner.

Salt administered in solution twice daily cannot be tolerated so well as equal amounts of salt ingested with the feed. However, the consumption of feed after the administration of toxic doses of salt by injection into the crop, does not alleviate the symptoms produced nor prolong the life of the bird to an appreciable extent.

The minimum lethal single dose of salt for birds weighing from 3 to 5 pounds is close to 4 grams per kilogram of body weight. Most of the birds so treated survive, tho a few may succumb within 24 hours. Birds given 3 grams of salt per kilogram of body weight survive the treatment.

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